Introduction

- Completely new microarchitecture with very little in common with other Intel PC processors
- Designed with 3 primary goals:
  - Dramatically reduce power consumption
  - Sufficient performance for a full internet experience
  - Full x86 compatibility

http://wwwslashgear.com/microsoft-pushing-for-16-core-atom-cpus-28129072/
Markets

- Low-cost subnotebook computers (netbooks)
- Low-cost desktop PCs (nettops)
- Mobile internet devices (MIDs)
  - Handheld computers with wireless internet connectivity but without conventional keyboards
## Silverthorne
(2008, MID market)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Intel Atom Z500</th>
<th>Intel Atom Z510</th>
<th>Intel Atom Z530</th>
<th>Intel Atom Z540</th>
<th>Pentium M ULV 733J</th>
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<tbody>
<tr>
<td>Core freq</td>
<td>800MHz</td>
<td>1.1GHz</td>
<td>1.60GHz</td>
<td>1.8GHz</td>
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<td>400MHz</td>
<td>533MHz</td>
<td>533MHz</td>
<td>400MT/s</td>
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<tr>
<td>Hyper-threads</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
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<td>TDP</td>
<td>650mW</td>
<td>2.0W</td>
<td>2.0W</td>
<td>2.4W</td>
<td>5W</td>
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<td>Avg Power</td>
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<td>220mW</td>
<td>220mW</td>
<td>5W</td>
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<tr>
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<td>0.75V-1.1V</td>
<td>0.75V-1.1V</td>
<td>0.75V-1.1V</td>
<td>0.81-0.96V</td>
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<td>26mm²</td>
<td>26mm²</td>
<td>87mm²</td>
</tr>
<tr>
<td>Instructions</td>
<td>32bit</td>
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</tr>
</tbody>
</table>

Memory Hierarchy

- **L1 Cache:**
  - 36K Instruction cache; only 32K available for use
  - 24K Data cache
  - Instruction and data cache have only 1 read port and 1 write port each

- **512K L2 Cache**

http://www.anandtech.com/show/2493/13
Low Power Philosophy

- Target: 90% lower power than 90nm Pentium M (Dothan)

- Discard previous x86 microarchitectures
  - Too heavyweight; too power-hungry
  - Start with simple design and add capabilities

- Additional features must provide 1% performance for 1% power
  - Reject anything requiring 2-3% power increase for 1% performance gain
Atom Design Decisions

Discarding Previous Microarchitectures

- No out-of-order processing
  - Too much logic to shuffle instructions
  - Not enough benefit for the power required
- No aggressive speculation
- No x86 instruction transformation (micro-ops)
  - Almost: the most complicated instructions are still split into multiple instructions, executed in parallel
Atom Design Decisions
Low-Power Performance

- 45nm technology
- In-order, dual-issue 16-stage instruction pipeline with a second integer pipe
- Two instruction decoders
  - Finding variable-length instruction boundaries takes up to 3 cycles.
  - Instruction cache marks ends of instructions.
  - Hits in the I-cache can skip these extra cycles.
Atom Design Decisions

Hyper-Threading

- 2-way SMT
- Boosts performance by 36-47%
- Increases power consumption by 17-19%
  - Hyper-threading requires more logic and an extra register file, resulting in more power consumption
- Increases die area by 8%
- Major bang for the power and area cost
Atom Design Decisions
Programmable features

- Number of outstanding I/O requests buffered on the FSB
- Parts of the L2 cache can be shut down
- Set-associativity programmable, from 2 to 8 ways
- Enhanced Speed-Step technology
Atom Design Decisions

Power States

- Multiple x86 power states
- From full power (C0) to deep-sleep (C6)
- C6 uses 1.6% of TDP
  - When entering C6 mode
    - Processor saves all state information, stops the clocks and shuts down FSB, goes to sleep
  - Coming Back
    - Restart clocks, restore state information, reprime pipeline
    - Atom gradually refills caches on demand to conserve power
  - Can switch from C6 to C0 in less than 100 microseconds
Atom Design Decisions

Dark Silicon?

- Modular microarchitecture
- Can disable 64-bit x86 extensions, virtualization extensions, Hyper-threading
- Can offer chips with either CMOS transceiver logic or Advanced Gunning Transceiver Logic; both are built into the chip
## Notable Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Intel Atom Z560</th>
<th>Intel Atom N270</th>
<th>Intel Atom N475</th>
<th>Intel Atom D525</th>
<th>Intel Core i7-610E</th>
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<tr>
<td>Core freq</td>
<td>2.13GHz</td>
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<td>1.83GHz</td>
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<td>DMI</td>
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<td>1</td>
<td>1</td>
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<td>0.8V-1.18V</td>
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Outstanding Questions

- How much MID market penetration does the Atom have?

- All of the netbooks being shipped with the Atom ship with 32-bit operating systems (as far as we have been able to determine), so why is the Atom 64-bit compatible?

- Since the Atom’s intended workload is internet-based, are 64-bit capabilities necessary?
Further Reading


Questions?